

# CLAIMS

## WHAT IS CLAIMED IS:

5           1. A method of supporting a user in mechanically analyzing a performance of an object, using an input device, a display device having a screen for display, and a computer connected to the input device and the display device, comprising:

10           a first step of graphically displaying on the screen a generalized model which is constructed as a numerical analysis model for the object such that the generalized model has been generalized with respect to at least configuration of a configuration, a structure, and a mechanism, of the object, and has been specialized with respect to a function of the object;

15           a second step of displaying on the screen an item for letting the user enter data using the input device in order to define a specialized model which is constructed as a numerical analysis model for the object by specializing the displayed generalized model with respect to the at least configuration thereof; and

20           a third step of mechanically analyzing the performance of the object, on the basis of the specialized model defined by the data entered by the user in association with the displayed item, a numerical analysis approach predetermined in correspondence with the function of the object, and a numerical analysis condition determined by the user or predetermined as a standard condition.

25           2. The method according to claim 1, wherein the numerical analysis model has a plurality of features representing geometrical properties of the

object in the form of a node having an attribute thereof and a discrete element having an attribute thereof.

3. The method according to claim 1, wherein the third step is for  
5 mechanically analyzing the performance of the object by directly using the specialized model defined in the second step.

4. The method according to claim 1, wherein the item is for letting  
10 the user enter using the input device, data for specializing the generalized model with respect to at least configuration of a configuration, a structure, and a mechanism, of the generalized model.

5. The method according to claim 1, wherein the second step  
15 comprises a fourth step of displaying on the screen in association with the displayed generalized model, a figure for supporting the user in graphically entering data for the item.

6. The method according to claim 5, wherein the item is used for  
20 letting the user enter numerical data, and the fourth step comprises a displaying step of displaying on the screen a figure for supporting the user in graphically entering the numerical data in association with the item.

7. The method according to claim 6, wherein the input device  
25 comprises a pointing device thereof, the displaying step comprises an input support step of displaying a bar, a pointer, or a cursor which is moved on the screen depending on an amount by which the user operates the pointing device of the input device, and which lets numerical data enter into the

computer depending on an amount by which the bar, the pointer, or the cursor has been moved, with respect to the item, to thereby support the user in entering the numerical data into the computer.

5           8. The method according to claim 6, wherein the input device comprises a keyboard thereof,

the second step further comprises:

a fifth step of displaying on the screen an indication letting the user directly enter the numerical data by operating the keyboard of the input device; and

a sixth step of selectively effecting the fourth step and the fifth step.

10           9. The method according to claim 1, wherein the third step comprises a seventh step of graphically displaying on the screen in association with the object, analysis results obtained from the numerical analysis model.

15           10. The method according to claim 9, wherein the analysis results comprise mechanical characteristic values for a segment of the object, and the seventh step comprises a displaying step of graphically displaying on the screen each one of the mechanical characteristic values, in the form of a figure which is changed in at least one of a size, a configuration, a pattern, and a color, of the figure, depending on a magnitude of the each one of the mechanical characteristic values.

20           11. The method according to claim 9, wherein the third step further comprises:

a eighth step of numerically displaying the analysis results on the

screen; and

a ninth step of selectively effecting the seventh step and the eighth step.

5           12. The method according to claim 1, wherein the object is a subject one of a plurality of components of a single product, which subject component has been selected by the user,

the generalized model is a subject generalized-model corresponding to the subject component, the subject generalized-model is one of a plurality  
10 of numerical analysis models respectively for the plurality of components, each of which has been generalized with respect to at least configuration of a configuration, a structure, and a mechanism, of each one of the plurality of components, and has been specialized with respect to a function of the each component,

15           the first step comprises a displaying step of displaying the plurality of components distinguishably from each other on the screen, of displaying an indication on the screen for letting the user select as the subject component one of the plurality of components, and of graphically displaying on the screen one of the plurality of generalized models which corresponds to  
20 the subject component which has been selected by the user in response to the indication,

the third step comprises an analyzing step of mechanically analyzing a performance of the subject component, on the basis of the specialized model defined by data which have been entered by the user in association with the  
25 displayed item on the screen, the numerical analysis approach predetermined in correspondence with the function of the subject component, and the numerical analysis condition.

16.

13. A method of supporting a user with a computer, in mechanically analyzing a performance of one of a plurality of components of a single product, which one component has been selected by the user, comprising the steps of:

mechanically analyzing the performance of a subject component which is one of the plurality of components which has been selected by the user, on the basis of (a) a subject numerical analysis model which has been selected by the user as one of a plurality of numerical analysis models respectively for the plurality of components, each of which models has been generalized with respect to at least configuration of a configuration, a structure, and a mechanism, of each one of the plurality of components, and has been specialized with respect to a function of the each component, and each of which models has been defined by data entered into the computer by the user, (b) a numerical analysis approach which is predetermined in correspondence with the function of the subject component, and (c) a numerical analysis condition which is determined by the user or predetermined as a standard condition; and

displaying analysis results obtained in the analyzing step, on a screen of the computer.

17.

14. A method of supporting a user in mechanically analyzing a performance of an object, using an input device, a display device having a screen for display, and a computer connected to the input and the display device, the improvement of the method comprising:

a construction support step usable before a specialized model has been defined by the user's converting a generalized model into the

specialized model, the generalized model serves as a numerical analysis model for the object, has been generalized with respect to at least configuration of a configuration, a structure, and a mechanism, of the object, has been specialized with respect to a function of the object, and has a plurality of features representing geometrical properties of the object in the form of a node having an attribute thereof and a discrete element having an attribute thereof, the specialized model is obtained by specializing the generalized model with respect to the at least configuration,

the construction support step is used to display on the screen an indication for supporting the user in constructing the generalized model by the user's defining the node and the discrete element using the input device.

<sup>18</sup>  
~~16~~. The method according to claim ~~14~~<sup>17</sup>, wherein the construction support step comprises:

a node definition support step of, in response to an action that the user identifies, for defining the node, a location at which the node is to be established, on the screen using the input device, displaying a node figure representative of being the node, at the identified location, and, in response to an action that the user indicates the displayed node figure, displaying a first support indication for supporting the user in setting the attribute of the node which has been represented by the displayed node figure; and

a discrete element definition support step of, in response to an action that the user identifies, for defining the discrete element, a location at which the discrete element is to be established, on the screen using the input device, displaying a discrete element figure representative of being the discrete element, at the identified location, and, in response to an action that the user indicates the displayed discrete element figure, displaying a second support

indication for supporting the user in setting the attribute of the discrete element which has been represented by the displayed discrete element figure.

5 <sup>19</sup>16. The method according to claim <sup>18</sup>15, wherein the discrete element comprises a beam element having an attribute thereof,

the attribute of the beam element comprises at least one of a cross-section shape of a real member represented by the beam element, a thickness of the real member, and a material property of the real member,

10 the discrete element definition support step comprises a beam-element definition support step of, in response to an action that the user identifies, for defining the beam element, a location at which the beam element is to be established, on the screen using the input device, displaying a beam-element figure representative of being the beam element, at the  
15 identified location, and, in response to an action that the user indicates the displayed beam-element figure, displaying as the second support indication, an indication for supporting the user in setting the attribute of the beam element which has been represented by the displayed beam-element figure.

20 <sup>20</sup>17. The method according to claim <sup>19</sup>16, wherein the attribute of the beam element comprises a cross-section shape of the real member represented by the beam element,

the method further comprises a cross-section shape displaying step of, once the user sets the cross-section shape depending on the second support  
25 indication, graphically displaying the set cross-section shape on the screen.

<sup>21</sup>18. The method according to claim <sup>18</sup>15, wherein the discrete element

comprises a panel element having an attribute thereof,

the attribute of the panel element comprises at least one of a thickness of a real member represented by the panel element, and a material property of the real member,

5 the discrete element definition support step comprises a panel-element definition support step of, in response to an action that the user identifies, for defining the panel element, a location at which the panel element is to be established, on the screen using the input device, displaying a panel-element figure representative of being the panel element, at the  
10 identified location, and, in response to an action that the user indicates the displayed panel-element figure, displaying as the second support indication, an indication for supporting the user in setting the attribute of the panel element which has been represented by the displayed panel-element figure.

15 <sup>22</sup>~~19~~. The method according to claim <sup>18</sup>~~16~~, wherein the discrete element comprises a design domain, a structure of which is intended to be designed by a topology optimization for achieving a required function, the design domain has an attribute thereof,

20 the attribute of the design domain comprises a condition on the structure to be adapted to the design domain,

25 the discrete element definition support step comprises a design-domain definition support step of, in response to an action that the user identifies, for defining the design domain, a location at which the design domain is to be established, on the screen using the input device, displaying a design-domain figure representative of being the design domain, at the identified location, and, in response to an action that the user indicates the displayed design-domain figure, displaying as the second support indication,



an indication for supporting the user in setting the attribute of the design domain which has been represented by the displayed design-domain figure.

29.

20. The method according to claim 17, wherein the object is a product  
 5 constructed by a combination of a plurality of parts, an organizational relationship according to which the plurality of parts are associated with each other is hierarchal,

the method further comprises a whole generalized-model construction step of, when the user sets the organizational relationship using  
 10 the input device, in response to an event that the generalized model has been constructed for each of the plurality of parts as a partial generalized-model, integrating a plurality of partial generalized-model respectively constructed for the plurality of parts, according to the set organizational relationship, to thereby automatically construct a whole generalized-model representative of  
 15 the whole of the product.

24.

21. The method according to claim 17, further comprising a  
 reconstructing step of storing as a template procedures in which the  
 generalized model has been constructed by the user using the input device,  
 20 into a memory of the computer, and, in response to a specific command from the user, reading out the template from the memory for thereby automatically reconstructing the same generalized model.

13.

22. The method according to claim 1, wherein each of a plurality of  
 25 sets of data representative of the generalized model, the specialized model, the numerical analysis approach, and the numerical analysis condition, respectively, has been constructed in an executable format in which the each

set of data can be executed by an operating system installed in the computer, without causing the computer to execute a special application program.

23. A computer program to be executed by a computer to implement  
5 the method according to claim 1.

24. A computer-readable storage medium having stored therein the  
computer program according to claim 23.

25. A system including an input device, a display device having a  
10 screen for display, and a computer connected to the input device and the  
display device, thereby supporting a user in mechanically analyzing a  
performance of an object, comprising:

a first means for graphically displaying on the screen a generalized  
15 model which is constructed as a numerical analysis model for the object such  
that the generalized model has been generalized with respect to at least  
configuration of a configuration, a structure, and a mechanism, of the object,  
and has been specialized with respect to a function of the object;

a second means for displaying on the screen an item for letting the  
20 user enter data using the input device in order to define a specialized model  
which is constructed as a numerical analysis model for the object by  
specializing the displayed generalized model with respect to the at least  
configuration thereof; and

a third means for mechanically analyzing the performance of the  
25 object, on the basis of the specialized model defined by the data entered by  
the user in association with the displayed item, a numerical analysis  
approach predetermined in correspondence with the function of the object,

and a numerical analysis condition determined by the user or predetermined as a standard condition.

26. A system for supporting a user in mechanically analyzing a performance of an object, using an input device, a display device having a screen for display, and a computer connected to the input device and the display device, comprising:

a first displaying area for graphically displaying on the screen a generalized model which is constructed as a numerical analysis model for the object such that the generalized model has been generalized with respect to at least configuration of a configuration, a structure, and a mechanism, of the object, and has been specialized with respect to a function of the object;

a second displaying area for displaying on the screen in association with the displayed generalized model, an item for letting the user enter data using the input device in order to define a specialized model which is constructed as a numerical analysis model for the object by specializing the displayed generalized model with respect to the at least configuration thereof; and

a third displaying area for graphically displaying on the screen in association with the object, in response to the user's entry of the data in association with the displayed item, results from a numerical analysis for the performance of the object.

27. A system including an input device, a display device having a screen for display, and a computer connected to the input device and the display device, thereby supporting a user in mechanically analyzing a performance of an object, the improvement of the system comprising:

a construction support means, operable before a specialized model has been defined by the user's converting a generalized model into the specialized model, the generalized model serves as a numerical analysis model for the object, has been generalized with respect to at least configuration of a configuration, a structure, and a mechanism, of the object, has been specialized with respect to a function of the object, and has a plurality of features representing geometrical properties of the object in the form of a node having an attribute thereof and a discrete element having an attribute thereof, the specialized model is obtained by specializing the generalized model with respect to the at least configuration,

the construction support means for, in operation, displaying on the screen an indication for supporting the user in constructing the specializing model by the user's defining the node and the discrete element using the input device.